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February 22, 2019

Via E-Mail

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Subject: AK Steel Dearborn Works – Civil Action No. 15-cv-11804
DJ # 90-5-2-1-10702

In accordance with the Consent Decree in the above-referenced action, attached is the Paragraph 21 report regarding the annual inspection of the ESP. Inspections of ESP compartments 1-8 as well as the rapper system associated with those compartments was conducted from June 12-14, 2018. An inspection report was submitted to AK Steel on August 15, 2018 and AK Steel's analysis of the report was submitted to EPA and MDEQ on October 5, 2018. A separate inspection was conducted on the off –gas conditioning system from August 29-31, 2018. The inspection report was submitted to AK Steel on January 4, 2019. AK Steel's analysis of the findings in that report is the subject of this submittal.

The Consent Decree requires that AK Steel provide an analysis of the report's findings and steps taken, if any, and steps to be taken, if any, for repair or improvement of operation of the ESP and a timely schedule for implementation. Recommendations and repairs are summarized on page 11 and 12 of the attached report.

AK Steel concurs with the recommendations specified in section 6.1.3, 6.1.9, and 6.1.12 of the attached report. AK Steel concurs with the recommendations specified in section 6.1.6, 6.1.8 and 6.1.10 of the attached report with the following comments:

6.1.6: Ensure that the rapping systems are fully functional and rap hard enough to clean the unit properly, especially in the A-fields.

AK Steel agrees with this recommendation and believes that it is already being implemented. The inspection report submitted on October 5, 2018 provided recommendations for repairs related to the proper functioning of the rapping system. In addition, AK Steel's O&M Plan for the ESP includes two quarterly inspections that evaluate the operation of the rapping system.

6.1.8: During a furnace outage the hood doors should be opened, and each bank of sprays operated so that bad nozzles can be repaired.

AK Steel performed this inspection in 2018 as a follow-up to the 2017 inspection and believes that some sort of inspection of this type is appropriate to ensure that bad nozzles are identified and repaired or replaced. However, AK Steel reserves the right to investigate and implement alternative monitoring techniques if it deems that the alternative is a more effective way of determining if there are defective nozzles.

6.1.10: The steam injection system should be programmed to vary the steam injection during different phases of operation.

AK Steel concurs with this recommendation and has implemented such programming. However, AK Steel reserves the right to implement steam programming based on its own observations that does not necessarily agree with the programming suggested by the contractor in the inspection report (P. 10-11 of the attached report).

AK Steel previously implemented the recommendation specified in section 6.1.1 based on the 2017 report and no further action is warranted.

The recommendations specified in sections 6.1.4, 6.1.5, and 6.1.11 were included in the 2017 inspection report. AK Steel previously identified its disagreement with those recommendations in its letter dated January 31, 2018.

AK Steel disagrees with the recommendations specified in sections 6.1.2 and 6.1.7 of this report. The reasons for the disagreement are discussed below:

6.1.2: Maintain a flow rate of 120-150 gpm through spray banks 1-7.

AK Steel agreed that a minimum of 13 spray nozzles (allowing a target flow of 120 to 150 gpm) was appropriate as a follow-up to the 2017 inspection. However, subsequent observations have revealed that setting a cap on the minimum number of spray banks in service causes serious safety concerns. The primary concern is that too much spray water causes water to run down the vessel hoods and accumulate underneath the vessels where it poses an explosion hazard. Flexibility is needed to make adjustments to mitigate this problem. In addition, upon further discussion with the contractor, it was indicated that this recommendation was made with the idea of reducing the risk of lance pulls due to high off gas temperature. This has the potential to provide greater production reliability but would not necessarily improve ESP performance.

6.1.7: The bank 9 sprays should be checked for proper operation and atomization and the flow returned to the previous observed levels (150 – 180 gpm).

AK Steel agrees that the bank 9 sprays should be checked for proper operation and atomization. Refer to the response to item 6.1.8 as bank 9 sprays are inspected along with the other spray banks. AK Steel disagrees with the recommendation to return the flow to previous observed levels (which were levels observed in 2014-2015) for the reasons discussed in the evaluation of item 6.1.2.

AK Steel has already initiated or completed many of the items discussed above for which it expresses agreement. AK Steel anticipates completing the work no later than the end of 2019.

If you have any questions regarding this report, please contact Jim Earl at 313-845-3217.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

LaDale Combs
General Manager, Dearborn Works

Submitted to AK
1/4/19

Dearborn Works - ESP Operational Review Report
TRK Engineering to: david.pate
Cc: jim.earl

01/04/2019 07:55 AM

History: This message has been forwarded.

1 attachment

AKSD180901 AKSteel BOF Operational Review Report.pdf

Hi Dave,

Attached is the report. I thought it went out before the Holidays. Sorry for the delay.

Please forward it to all concerned parties and let us know if you have any questions.

Thanks,

Tom Keeler

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OPERATIONAL REVIEW REPORT

ELECTROSTATIC PRECIPITATOR
GAS CONDITIONING SYSTEM
BOF FACILITY

AK Steel
Dearborn, Michigan

Dates of Trip
August 29 – 31, 2018

Prepared by
Timothy P. Mallory

Reviewed by
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TRK Report # AKSD180901

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1. Purpose

TRK Engineering Services, Inc. was retained by AK Steel – Dearborn to observe the operation of the BOF facility electrostatic precipitator while the furnaces were in operation. These observations were then used to study the programming of the water spray systems to estimate their condition and locate any possible programming changes or operational modifications that could enhance the performance of the precipitator.

This report summarizes findings made during this inspection and details some of the observed modifications that were made since the last inspection. It also provides a work list for recommended maintenance repairs that TRK believes would enhance the operation of the gas conditioning system.

2. BOF Precipitator Operation Introduction

In the operation of a typical BOF facility precipitator the beginning and end of a heat create special operational difficulties not experienced by precipitators in other industries.

The dust driven off from a furnace during the initial part of a blow cycle contains an unusually large amount of Silica dust, primarily as SiO_2. This dust has an extremely high electrical resistivity and is difficult to charge within a precipitator. Also, the gases from the furnace tend to have very low moisture content. This is due to the nature of the process. The gases are mostly just ambient air mixed with high temperature off gases created from the oxygen blowing process, and the combustion of CO gas above the vessel. There is no real source of any humidity beyond that which exists in the ambient air.

The gas leaves the vessel at temperatures between 2800°F and 3100°F. In order to protect the boiler tubes above the vessel, water is added to the gas. Water and steam are also sprayed above the boiler to assist with conditioning the gases prior to the precipitator. The purpose for having some of the sprays after the boiler is so that they may be turned on sooner and the boiler will prevent the spray droplets from dropping back into the vessel. During most of the cycle, the addition of water lowers the resistivity of the dust while also moderating the temperature of the off gases. At the beginning of the cycle however, there is no heat to evaporate the water and the dust remains dry. This dust is then deposited on the collecting plates and creates a resistive layer that raises the voltage while lowering the output current of the precipitator. Once this resistive layer is created, it can only be removed by aggressive rapping. Even then, it can take hours to fully remove this dust.

To further combat the accumulation of dry dust, most BOF facilities introduce steam and/or air assisted water sprays after the boiler (in the case of the Dearborn facility, both are used). This moisture contacts the dust and provides an electrical path around the surface of the particles, thus effectively lowering the resistivity of the dust as it is presented to the precipitator. This pre-treatment of the gases can effectively reduce the startup effects in the precipitator. This is why the timing of the various water sprays is so often a topic of discussion when opacity spiking at the onset of a heat is an issue.

If the precipitator itself is cold, as it is whenever a production gap occurs, this moisture may condense onto the collecting plates or the hopper walls. In these cases, the results can be the creation of mud that can be difficult to remove from the system. If the collecting plates become too wet, then the rapping system will not have any impact until the layer dries. This usually is cooked dry during the heat; however, the baked dust may cement itself together and the rappers may not be capable of breaking the crust. This type of layering will generally be apparent during internal inspections.

During the closing minutes of a heat a similar effect to that which is experienced in the beginning arises. During this phase, the silica is now removed as is the majority of the carbon. With no further fuel, the process simply converts iron to iron oxide. Iron oxide has a very low resistivity and requires a very high operating current from the precipitator to retain the dust. Unfortunately, without fuel, the process rapidly cools from the constant influx of ambient air drawn into the ducts. This causes the water system to shut down in a cascade to prevent water fall out.

Usually this is not an issue since the remaining dust is quite low in resistivity and easier to collect. If the unit has issues at the beginning of the cycle however, the residual highly resistive layer may prevent proper collection of the low resistivity dust later on. This follow on type effect is marked by an opacity spike just after the water systems shut off and has been observed at the Dearborn facility.

In order to mitigate this effect, the rapping systems may need to operate more aggressively, even possibly during the heats. Another alternative is to adjust the water systems to turn back some of the nozzles faster so that others can remain on slightly longer near the end of the heat.

These items are very specific to the operation of a BOF. One singularly important item remains that applies to all electrostatic precipitators. This is the fact that the performance of the equipment is utterly dependent on the amount of gas flow through it.

As it applies to a BOF, the gas flow must be sufficient to provide two (2) things:

1) It must be sufficient to ensure that all of the CO gas is combusted so that the risk of explosion is reduced to an acceptable level. And,
2) it must provide a negative draft, so the fumes are indeed drawn out of the building and through the equipment.

These two (2) items both entail safety concerns and cannot be overlooked. Reducing the gas flow appears simple at the outset but becomes far more difficult once all of the safety concerns are properly recognized.

3. Description of the Existing System

The ESP at the AK Steel Dearborn Works BOF facility consist of four (4) side by side dual chamber precipitators manufactured by Western Precipitation in 1963. Each chamber includes the space for five (5) mechanical fields designated as fields A through E. Field B however has never been populated with the internal components and remains as an empty drop out area. Each chamber includes 30 gas passages in the A field while the C, D and E fields each have 34. The difference is based on a gas passage spacing of 10" used in the A fields vs. a spacing of 9" in the other fields.

The BOF facility itself is a two (2) vessel operation utilizing a vessel size of approximately 285 tons to produce 250-ton heats of steel. The remainder of the facility is a single ladle type shop. There is a single r desulfurization/skimming system and a single hot metal transfer station. The normal production appears to range from 30 to 35 heats per day. The shop is nearly capable of this production with only a single vessel which allows for one vessel to be offline for maintenance with minimal impact.

The gases developed in the furnace are drawn up into the primary hood where the CO is combusted. They then pass through seven (7) rows of simple, flat-cone, hydraulic pressure type water sprays to cool the gases prior to the boiler. These sprays utilize 200 psi water, and make a relatively course spray that requires high temperatures and high flow velocities to entrain and evaporate the droplets. The large droplet size in return allows for excellent dust particle agglomeration when these sprays are in operation. The gases then pass through the boiler. These nozzles are controlled by the gas temperature and are presently set as follows:

	"A" Vessel		"B" Vessel	
Spray bank 7:	On: 325°F	Off: 275°F	On: 350°F	Off: 270°F
Spray bank 5:	On: 350°F	Off: 300°F	On: 350°F	Off: 275°F
Spray bank 6:	On: 450°F	Off: 400°F	On: 450°F	Off: 400°F
Spray bank 2:	On: 490°F	Off: 440°F	On: 490°F	Off: 440°F
Spray bank 1:	On: 550°F	Off: 500°F	On: 550°F	Off: 460°F
Spray bank 3:	On: 615°F	Off: 525°F	On: 575°F	Off: 500°F
Spray bank 4:	On: 575°F	Off: 485°F	On: 615°F	Off: 565°F

Above the boiler are the number 9 and number 8 banks of water sprays, which are of the air assisted type, and produce smaller water droplets. The number 9 spray bank is actually the next row in the gas stream after bank number 7. This bank utilizes four (4) large air assisted nozzles. The original programming was designed to turn on these four (4) nozzles all together when the temperature of the gas reached 250°F, and turn them back off if the temperature fell below 230°F.

Much higher in the hood near the hood outlet is bank number 8 which consists of 10 air assisted nozzles. These nozzles are smaller than those used in bank number 9. The number 8 spray bank's programming was set up as follows:

"A" Vessel Bank 8 Nozzles

Nozzles 2, 3, 4, 5:	On: with O_2	Off: with O_2	40 gpm (50 minimum total)
Nozzles 1, 6:	On: 230°F	Off: 180°F	60 gpm
Nozzles 7, 12:	On: 305°F	Off: 255°F	80 gpm
Spray bank 4:	On: 330°F	Off: 280°F	90 gpm

"B" Vessel Bank 8 Nozzles

Nozzles 2, 3, 4, 5:	On: with O_2	Off: with O_2	80 gpm (100 minimum total)
Nozzles 1, 6:	On: 230°F	Off: 180°F	120 gpm
Nozzles 7, 12:	On: 305°F	Off: 255°F	160 gpm
Spray bank 4:	On: 330°F	Off: 280°F	180 gpm

After the hood, in the down comer duct is a steam injection port. This steam injection port was originally operated via a relay to come on whenever a heat begins and turn off 45 minutes after the heat is finished. The original facility was designed with no way to adjust the rate of flow of the steam which was assumed to be 40,000 #/hr.

The steam system was modified during the past year to be controlled by the PLC computer that controls the rest of the water supply system. The new programming seems to somewhat mirror the old relay in logic but allows for the adjustment of the steam flow.

The intention is that the steam would be initiated first. The sprays that make the smallest droplets are positioned high in the hood above the boiler, and are engaged next. Other sprays are added as the temperatures increase until the temperature stabilizes at the desired temperature. Unfortunately, in the original design, no direction was left as to the desired temperature. This created an issue over the long term where ever more water was being added to attempt to "correct" precipitator issues. Many times, this simply masked actual operations or maintenance problems.

To be clear on this, the worst point at which to operate a precipitator in BOF service is between 425°F and 475°F. This is where the peak of the resistivity curve for this material exists and is high enough that the effects of moisture are minimized. This is also exactly the range in which this precipitator routinely operates. For best operation the precipitator should either operate near 400°F with a continuous source of water when the furnace is in operation, or it should operate above 500°F.

Many other facilities have found that operation in the 600°F range allows for excellent operation, but the temperature is very difficult to maintain with a single desulfurization / skimming station, and single overhead crane. With normal blows lasting approximately 18-25 minutes, high temperature operation requires minimizing the downtime between heats to 5-10 minutes maximum. This also requires that the amount of cold air drafted between heats be kept to an absolute minimum. These goals do not seem realistic given the shop design, so it is likely best to concentrate on providing good operation in the lower temperature range. This requires lowering the temperatures to the precipitator by 50°-150° while attempting to deal with corrosion issues in the back of the unit.

4. Normal Operation

Over many years, TRK and plant personnel have worked together to fine tune the operations of the water sprays on an ongoing basis. One of the lessons learned over this time is that the system must be tuned to add more water faster at the beginning of the heats in the summer months and then returned to its previous programming in the fall. This is due to the effects of the warmer and cooler intake air in the system. If too much water is added in the winter months, the precipitator tends to become blocked with mud, and the hoppers and conveying systems become untenable. If the winter settings are utilized in the summer months, the system creates larger opacity spikes at the beginning and ends of the heats.

Most of the changes between winter and summer operation are made through adjustments to the number 7, 8, and 9 banks sprays. The steam flow is normally changed at other plants, but this plant previously did not have that capability.

The typical winter settings were historically set as follows:

Spray bank 7:	On: 250°F	Off: 220°F
Spray bank 5:	On: 400°F	Off: 350°F
Spray bank 6:	On: 450°F	Off: 370°F
Spray bank 2:	On: 490°F	Off: 410°F
Spray bank 1:	On: 550°F	Off: 460°F
Spray bank 3:	On: 575°F	Off: 485°F
Spray bank 4:	On: 615°F	Off: 525°F

The typical summer settings were:

Spray bank 7:	On: 200°F	Off: 170°F
Spray bank 5:	On: 400°F	Off: 350°F
Spray bank 6:	On: 450°F	Off: 370°F
Spray bank 2:	On: 490°F	Off: 400°F
Spray bank 1:	On: 550°F	Off: 460°F
Spray bank 3:	On: 575°F	Off: 485°F
Spray bank 4:	On: 615°F	Off: 525°F

The purpose for the difference in winter and summer operation is simply due to the difference in the outside temperature. Low winter temperatures expand any issues with the thermal insulation of the precipitator casings and ductwork, and cause more issues with condensation. This breeds corrosion and hopper flow troubles. In each case the intent is to leave two clear areas for operation of the precipitator. The temperature zone between 350°F and 440°F and the temperature zone between 500°F and 575°F. This helps the precipitator avoid the area of operation between 440°F and 500°F where the dust resistivity would be at its highest.

Many times, people will refer to changes in the spray water programming as "adding water" or "removing water". This is inaccurate as these changes do not materially change the flow of water to the system. They simply raise the temperature. The water flow is based on the temperature and latent heat of the gas. Actually, reducing the water flow would simply result in a raising of the temperature until other sprays were engaged. Retarding too many sprays would eventually lead to an unsustainable outlet temperature that would trip the system offline.

The normal operation of the number 8 bank sprays initiates the sprays whenever the main draft damper is moved beyond 75%. This allows the spray to be in service as the gases begin. If the O_2 is not initiated within 30 seconds, then the bank 8 sprays are turned back off. The minimum flow of water is varied by the time of year. Historically, in the summer this was generally set to 100 GPM. The winter setting was 80 GPM.

5. Operational Findings

During this visit, TRK surveyed the present state of all of the operational settings. Some changes are normal, as people attempt to fine tune the system over time. This can be a somewhat trial and error procedure at times, and so good record keeping of the settings is important. This allows for unsuccessful trials to be reset. The following represents the settings as found during this visit.

	"A" Vessel		"B" Vessel	
Spray bank 7:	On: 325°F	Off: 275°F	On: 350°F	Off: 270°F
Spray bank 5:	On: 350°F	Off: 300°F	On: 350°F	Off: 275°F
Spray bank 6:	On: 450°F	Off: 400°F	On: 450°F	Off: 400°F
Spray bank 2:	On: 490°F	Off: 440°F	On: 490°F	Off: 440°F
Spray bank 1:	On: 550°F	Off: 500°F	On: 550°F	Off: 460°F
Spray bank 3:	On: 615°F	Off: 525°F	On: 575°F	Off: 500°F
Spray bank 4:	On: 575°F	Off: 485°F	On: 615°F	Off: 575°F

"A" Vessel Bank 8 Nozzles

Nozzles 2, 3, 4, 5:	On: with O_2	Off: with O_2	40 gpm (50 minimum)
Nozzles 1, 6:	On: 230°F	Off: 180°F	60 gpm
Nozzles 7, 12:	On: 305°F	Off: 255°F	80 gpm
Spray bank 4:	On: 330°F	Off: 280°F	90 gpm

"B" Vessel Bank 8 Nozzles

Nozzles 2, 3, 4, 5:	On: with O_2	Off: with O_2	80 gpm (100 minimum)
Nozzles 1, 6:	On: 230°F	Off: 180°F	120 gpm
Nozzles 7, 12:	On: 305°F	Off: 255°F	160 gpm
Spray bank 4:	On: 330°F	Off: 280°F	180 gpm

These settings are considerably different than the settings used previously. No explanatory information was available as to the reasons for the reprogramming. It is interesting that the settings on the A and B vessels are different from one another.

The first thing noticed was that the initial spray prior to the furnace (bank 7) turns on at 325°F on A vessel and at 350°^{0} F on B vessel. For Vessel B, both bank 7 and 5 turn on at the same time. TRK would advise changing the bank 7 sprays on both vessels to have an on setpoint of 250°F in the winter and 200°F in the summer. In both cases, TRK believes that the dead band should be maintained at 30°F. It is our belief that the present setpoint is too high and allows too much hot gas into the boiler tubes without any water addition.

5.1. Spray Banks 1 through 7

The actual condition of these nozzles is unknown. The listing on the left side of the following picture indicates that many nozzles are out of service. Based on the flows, I suspect this is correct. In watching the operation, it was noted that all the spray banks now operate on most heats. This is unusual. In previously observed conditions, spray banks 3 and 4 almost never turned on. These could be referred to be emergency nozzles, since they would operate only during a heat that was unusually hot. This allowed the system to accommodate problem heats. With all the nozzles in normal operation, the system has no reserve for a runaway heat. This would mean that a hot heat would cause a furnace trip.

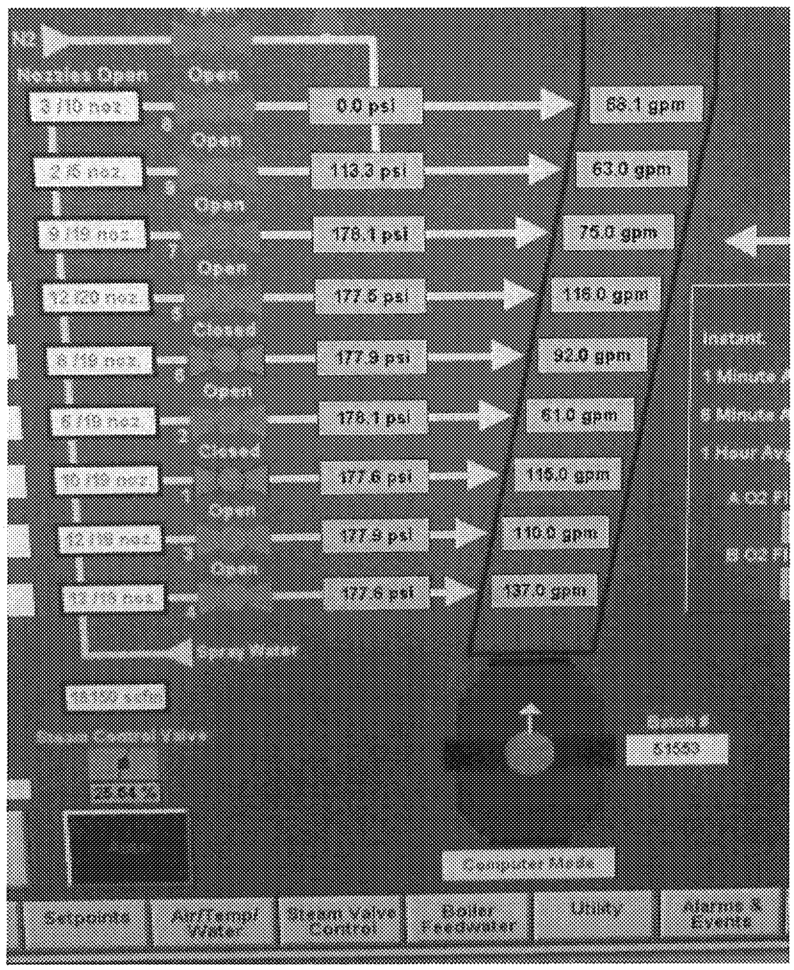

Figure 1: B Vessel water sprays

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As can be seen in Figure 1, the flow through each of the 1-7 banks of sprays are between 63 and 137 gpm. With all the nozzles in full operation, there would be approximately 150 gpm at each operating spray bank. Under normal conditions, 120 gpm per operating spray bank is common. By reducing the flow through each bank of nozzles, the system is simply forced to operate at a higher temperature in order to turn on successively more nozzle banks. This results in an average heat such as above operating with every bank in operation.

The problem with this type of operation is that any failure of one valve or any "hot" heat will simply trip the furnace and open the roof stack.

In the past, each of the spray banks 1 through 7 were operated at 120-150 gpm with new nozzles, and then once in operation, the boiler maintenance crews would locate the two nozzle banks that operated near equilibrium and adjust the flow of those two banks to provide smooth temperatures. Generally, nozzle banks 7 and 5 operate through the majority of every heat, and banks 6, 2, and 1 operate during the last half of each heat. Under normal conditions, banks 3 and 4 were not used except as backups. Some of the extended water flow may be attributable to higher blow rates than previously observed creating higher heat loads on the system.

5.2. Spray Bank 9

Bank 9 was originally programmed with a set point to turn the spray on at 250°F, the system was overridden in the PLC computers some years ago to bypass this set point and turn this bank on as soon as a blow began. There were two (2) issues with this. The first issue was that the PLC program code that turned the spray back off at 230°F was not changed. This created a pulsing operation. Both the turn on and turn off lines of code had 2 second delays built in to allow for valve timing and PLC update time. This meant that as long as the O_2 was on and the temperature of the gas was below 230°F, the system would turn on bank 9 for 2 seconds, and then turn it off for 2 seconds, continuously.

Another issue with this arrangement is that the air/nitrogen system included a flow control type valve. This has a stoke time and never opened during these two second pulses. This created an environment where the spray nozzles were operating without air which poured water down through the boiler ducts toward the vessel. The number 9 spray bank nozzles were never designed to operate in a cold environment. The original model study indicated that these nozzles stood a high likelihood of depositing mud in the hood if operated early in the heat.

In 2013, the system changed back to the original set point type operation, but with the set point to turn on the number 9 bank set to 150°F as long as the O_2 is on. The turn off set point was changed to 130°F. This programming appears to still be intact, but the number 9 sprays historically had a flow rate of 150-180 gpm and the observed flow rate now ranges from 30-65 gpm.

Perhaps this was turned down over the last few years as the plant had issues with the spray nozzle suppliers. The flow is now very low. The bank 9 sprays should be checked for proper operation and atomization and the flow returned to the previous levels.

5.3. Spray Bank 8

The last sprays in the system are on the 8th floor of the building and are the nozzles designed to be activated first. These nozzles were programmed so that the four (4) nozzles in the bottom side of the duct activated when the inlet damper associated with a vessel opened past 75%. If the blow did not begin within 30 seconds, the water would be turned off to prevent wetting the stack walls. Then the other nozzles add in a cascade as the temperature increases until they are all on. The air to the nozzles did not change. This created a far higher air to liquid ratio when only four (4) nozzles were in service and provided very fine droplets designed to float upwards with the gas even without high temperatures.

During this visit, it was noted that the flow on the A vessel sprays have all been set very low relative to what has historically been observed. In TRK's opinion, the air does not seem high enough on either vessel during operation. If there are issues with these sprays working correctly, then they should be investigated and repaired.

5.4. Steam Injection

There is a steam injection system which was installed when the plant was built in 1963. The system was originally controlled by relays embedded in the control consoles in the plant. When the furnace was designed this system was set up to utilize some 40,000 #/hr. of steam. A couple of years ago, a flow meter was added to the system indicating that the actual amount of steam injection is approximately 53,000 #/hr. when it is activated. The steam flow is now indicated in the plant DCS system. The valve that controls the steam system is a motorized control valve and has since been added to the DCS so that the steam flow can be adjusted.

Presently, the programming was designed to simply recreate the logic that had been used in the old, relay system. This should be modernized. In the old relay steam system, the steam would initiate when a blow began. The steam would then continue until 45 minutes after a blow. This time was used so that under normal conditions the steam would be on for charging the next heat. This pumps a lot of unnecessary steam into the precipitator when the system is cold between heats.

We would recommend the following logic:

- Initiate the steam when the vessel controls are set to charge and set the steam flow to 10,000 #/hr. in the summer or 5,000 #/hr. in the winter.
- When oxygen is flowing, increase the steam flow to 40,000 #/hr. in the summer and 8,000 #/hr. in the winter.

- 3 minutes after oxygen stops, drop the steam flow to 5,000 #/hr. in the summer or 3,000 #/hr. in the winter. The intent is that this flow be maintained during the tapping process.
- If the vessel inlet damper closes to 30% or less, then drop the steam flow to 1,000 #/hr. in the summer or 1,000 #/hr. in the winter and hold this flow for up to 45 minutes. The intent of this is to maintain some flow so that the steam lines remain full of steam for the next heat.

This logic will reduce the usage of steam and will reduce the amount of steam that condenses into the precipitator dust between heats.

6. Recommendations and Repairs

The BOF facility is now over 50 years old. Even though the original design life was perhaps half of this, the facility remains in serviceable condition. The equipment remains operable, and, with maintenance, should serve many more years. The precipitator unit was adequately sized for its use when it was designed and should still be adequate to provide good performance so long as normal maintenance routines are followed. The system was also designed with provisions for easy expandability. These provisions should be considered in any eventual overhaul of the system.

The actual flow through the precipitator is largely unknown and needs to be detailed and corrected to ensure that the equipment is not simply being overloaded unnecessarily. The system flow varies with draft setting, blow rate, and the condition of the plant ductwork. All of these should be monitored carefully.

The water spray systems are in adequate repair and are large enough to serve the system. It is our understanding that there have been difficulties in determining the status of the air and water flows to the number 8 and 9 spray banks. Some investigation may be warranted into upgrades of instrumentation that could be useful in maintaining these systems. Further tuning of the PLC systems could be useful once the instruments are functioning properly. With the expanded oxygen blow rates, the system is beginning to show signs of a water shortage. The water pumps may not be adequate for the increased load.

In order to properly tune the system and safely change the computer controls, reliable feedback information and stable operation are of the upmost importance. For these reasons the following list of recommended repairs has been compiled. In TRK's opinion, these repairs would enhance the operation of the gas conditioning system.

6.1. Recommended Modifications and Additional Work

The following recommendations are made for future investigation or to provide enhancement to the system.

6.1.1. Investigate the air flow system on the bank 8 sprays.

6.1.2. Maintain a flow rate of 120-150 gpm through spray banks 1-7.

6.1.3. Locate the performance curves for the injection water pumps and determine their capability to provide adequate flow at higher blowing rates. These pumps need to always be capable of 150-300 gpm more flow than will be needed to provide a safety factor for volatile heats.

6.1.4. Reset the bank 1-7 sprays on both the A and B vessels as follows:

• Spray bank 7:	On: 250°F	Off: 220°F
• Spray bank 5:	On: 400°F	Off: 350°F
• Spray bank 6:	On: 450°F	Off: 370°F
• Spray bank 2:	On: 490°F	Off: 410°F
• Spray bank 1:	On: 550°F	Off: 460°F
• Spray bank 3:	On: 575°F	Off: 485°F
• Spray bank 4:	On: 615°F	Off: 525°F

6.1.5. Reset the bank 8 sprays on both vessels as follows:

• Nozzles 2, 3, 4, 5:	On: with O_2	Off: with O_2	80 gpm (80 minimum)
• Nozzles 1, 6:	On: 250°F	Off: 200°F	120 gpm
• Nozzles 7, 12:	On: 325°F	Off: 275°F	160 gpm
• Spray bank 4:	On: 350°F	Off: 350°F	180 gpm

6.1.6. Ensure that the rapping systems are fully functional and rap hard enough to clean the unit properly, especially in the A fields.

6.1.7. The bank 9 sprays should be checked for proper operation and atomization and the flow returned to the previous observed levels (150-180 gpm).

6.1.8. During a furnace outage the hood doors should be opened, and each bank of sprays operated so that bad nozzles can be repaired.

6.1.9. Ensure that the double tipping valves are operating correctly. These should not be tied open as this allows air to be sucked backwards up into the precipitator causing increased emissions and cooling the hopper area causing the hopper to plug.

6.1.10. The steam injection system should be programmed to vary the steam injection during different phases of operation.

6.1.11. The O_2 content of the gas in the down comer prior to the precipitator should be measured during the heat. This can be used to judge the accuracy of the flow through the hood, and the status of the ductwork.

6.1.12. Any large steam leaks in the vessel hoods should be repaired to prevent large amounts of steam injection into the precipitators between heats that cause corrosion and plugging.